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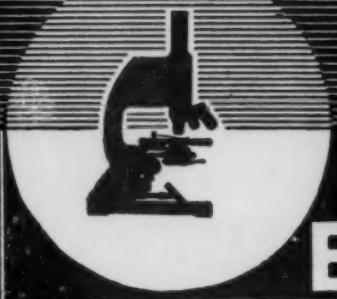

SCIENCE EDUCATION

THE SCIENCE MAGAZINE FOR ALL SCIENCE TEACHERS
FORMERLY GENERAL SCIENCE QUARTERLY

Astronomy and the Schools of Tomorrow

Competency in Science Teaching—Not Credit Hours—II

Types of Thought Questions in Textbooks of Science

A Synthesis of the Results of Twelve Curricular Studies in the Field of Science Education—II

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Volume 27 SEPTEMBER-OCTOBER, 1943 Number 2

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Science Education

ASTRONOMY AND THE SCHOOLS OF TOMORROW *

GEORGE W. HAUPT

State Teachers College, Glassboro, New Jersey

Teachers of science on all grade levels ask for guides to better curricula. The natural concepts give this direction. These concepts meet three criteria: (1) They inhere in all objects and processes. They define the structure and expression of nature. (2) They impel the questions of children; they belong to the play of infants and solve their problems. (3) They unify the thrusts of man's mind as told in the long history of science, for they uphold all of our scientific laws and principles. The natural concepts offer science education system, order, and harmony.

Space is one of the important natural concepts. Energy and matter manifest in space. Space embeds creation. Long before the child wants words and books he probes the mystery of form and action in space. The laws and principles of science explain creation in its terms. The history of science tells a story of toil to understand its relations. Astronomy, Mother of Sciences, taught her offspring the language of space. The concept of space touches the Absolute and yet both youth and sage sense it and seek understanding.

How many teachers unfold this concept? The gnomon marked out the plan for the firm base upon which our science raises and this same tool traces for the learner fundamental cosmic relations. The shadow stick images the grand patterns of space.

As the pupil watches the shadow of the sun from morning until evening he orients himself. Thus mankind fixed his cardinal points. Thus comes understanding of the horizon quadrants. North, East, South and and West place the child in Space—an horizon Space—part of a vast design. The shadow stick, the upright human body and the sun witness a relation. "Where am I?" asks every normal mind. And every day Nature answers.

This knowledge of horizon and cardinal points provides the student with a powerful astronomical instrument. The horizon decisively implemented the early astronomers. Now teach observations of the rising and setting of the sun. The concepts of altitude and zenith distance emerge. Space rounds. We build toward angles of space, of which altitude of the sun was perhaps the earliest measurement. Thinking approaches the sundial and appreciation of time. Altitude and zenith distance disclose new horizons and bestow mightier tools.

While all objects and processes proclaim space, Astronomy teaches the concept most perfectly for we experience space as a fundamental cosmic manifestation.

We should teach two vertical circles early in the grades. Historically, observations of culmination followed consideration of the horizon. Certainly the student of astronomy grasps understanding of the vertical circles soon after he appreciates significance of the horizon. The celestial meridian marks the midpoint of the daily transit of the sun and therefore merits early study. Then comes use of the prime vertical. Since these two circles extend from the four cardinal points their relation to the prior concepts of the horizon clarifies

* Prepared for the cancelled meeting of Section D (Astronomy), American Association for the Advancement of Science. New York City. December 29, 1942.

and comprehension of spacial concepts widens. Celestial meridian and prime vertical simplify astronomy and they weld numerous observations.

Then the celestial sphere. The celestial sphere gives our bearings for the new age —the air age. Man can no longer think and move relative only to the terrestrial sphere. The eyes of school children must scan the heavens. Uranography properly sets the space concepts of geography. Relate the celestial sphere to our terrestrial horizon. Teach the zenith and the nadir, the true polar point and the axis. The celestial sphere invests the lesser concepts of space with meaning for the problems of present living.

Children take well to spacial interpretations for their minds from birth seek its experiences.

The pupil gradually and naturally finds need for the divisions of the circle. The horizon taught him the quadrants. He placed a cross within a circle. He divided the circle by four. He perceived relation of the parts of a circle to time of day, for noon gave one angle of the sun and midnight another; sunrise one angle and sunset another. Degrees, minutes and seconds coordinate his sphere. As he travels northward his pole star rises, for the vastness of space walks with him. The divisions of the circle set the lessons of navigation.

And so arise considerations of angles. Students realize the value of the angle to astronomy and the meaning of angular distance. They learn how the circle measures angles. Early man calculated angular distance with the gnomon and the clepsydra and schools today may profitably do likewise. The method of the primitive dioptra interests the novice for he can make and use this instrument. Students appreciate the value of the micrometer and how all modern instruments fulfill the geometrical principles established by the ancients. Great thoughts subtend these angles of the sphere: azimuth, altitude, latitude, declination, right ascension, hour angle and celestial longitude.

Throughout the ages the concept of space yielded and integrated the immortal discoveries of astronomy.

The celestial equator parallels earth with sky. Lesser space repeats the greater. The course of the sun in March and September cleaves the heavens with a fundamental plane. The gnomon and the armillary ring of Hipparchus teach the same lesson for different levels of mental maturity. Simple observations of celestial equator contribute profound interpretations.

Why do we not teach something on all grade levels relative to the spacial relations of ecliptic and celestial equator, equinoctial and solsticial colures? We do explain the seasons and their association with ecliptic and equinoctial points but the lessons do not culminate from a background of interrelated spacial concepts. The spacial coordinates defined by ecliptic, celestial equator and the colures involve some of the most fundamental ideas of science. These spacial concepts belong to all objects and in all sciences; they constitute the keystone of scientific progress; they result from observations of the simple shadow stick and they can order and harmonize the whole science curriculum.

Once, a selective and aristocratic elementary education esteemed astronomy. That astronomy taught the natural geometry and its concepts equipped leaders. In the public schools of the United States astronomy waned until it became identification and superficial description. Now modern war and a new era expose our want and instructional problems of a post war world disclose our opportunity. An adequate educational program for the emerging democracies necessitates a graded program of astronomical concepts for all children and learners, from the Nursery School, through High School and University.

We know that teachers can direct children of all ages and all grade levels to profound thoughts by proper utilization of certain astronomical observations. The several observations selected for discussion here derive from the gnomon. All of these observations interpret space. Space is one of the great natural concepts because it molds all things and actions, the queries of the youngest minds and the investigations of the ablest scientists. Astronomers and educators must demand that the public schools gradually and progressively unfold this cardinal concept.

The spatial concept, pillar of the Temple of Knowledge, masterwork of Astronomy, bases the science curricula which now build.

COMPETENCY IN SCIENCE TEACHING—NOT CREDIT HOURS—II *

G. P. CAHOON

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PROVIDING APPROPRIATE EXPERIENCES

Obviously when one has planned for the kinds of evidence that students should be able to exhibit on such phases, it is suggestive of the kinds of experiences which might be provided. So often we have provided some experiences, usually reading and listening to lectures, and then of course we had to have the evaluation and evidence concerned with these. Simply collecting data from tests and other evaluation instruments and filing them in a student's folder, however, is inadequate, to say the least. These data are indicative of certain progress, or lack of it—toward the achievement of one or more phases in competency. They are evidences of weaknesses or of strengths. They represent needs. Appropriate experiences should be provided, in the light of these data, for each individual. And what are appropriate experiences for one, may be quite in appropriate for another.

Courses may be the most appropriate kinds of experiences for achieving certain aspects in competency. For others, different kinds of provisions and machinery need to be set up in order that students may get needed experiences. Among such might be some or all of the following: (1) Participation in schools during September before college opens; (2) Working with groups in social agencies, Sunday Schools, Boy Scouts, during the regular year; (3) Working in boys' or girls' camps during summer; (4) Working in factories, department stores, and the like; (5) Reading and writing; (6) Speaking before groups; (7) Participating in certain campus activities; (8) Tutoring high school pupils; (9) Taking part in panel discussions; (10) Making case studies of children; (11) Taking trips to various agencies and institutions; (12) Collecting bulletin board and pamphlet material; (13) Constructing evaluation instruments; (14) Making home made slides and operating projectors; (15) Planning units; (16) Working with shop and laboratory tools and apparatus.

Such activities would not be in the nature of "extra-curricular" activities. They should be part of a planned program for each individual, if they are to be effective in achieving desired competency. Of course, this is more difficult than herding all prospective teachers into the same courses and lecturing to them; but some such plan seems to be necessary if we are to achieve our goals. Good teaching on the "teacher-training" level seems to demand time and energy and planning and competent person-

* *Concluded from February issue, page 6.*

nel, as much as does good teaching on the secondary school level.

SETTING HURDLES AT VARIOUS STAGES

The kinds of hurdles which might be set up at certain stages have been suggested in the preceding discussion. It hardly seems fair nor logical to allow all who knock at the gates of a teacher preparing institution to stay within for a certain length of time and then release them all certified to teach. Very few supervisors have the heart to say during the final student teaching experience to even the obviously "weak sister," who has "put in" three and a half years, that he can't graduate or be certified to teach. He has met the requirements of the proper number of credit hours, and so is allowed to go out, with the hope that not too much discredit will be heaped upon his alma mater.

Perhaps hurdles could be set up at three or four places:

1. Selection—or admission to freshman standing.
2. Admission to junior standing.
3. Admission to student teaching.
4. Certification for teaching—or graduation.

To pass each hurdle a student would have to show evidence of possession of, or progress toward, certain phases in competency.

PHASES AND EVIDENCES OF COMPETENCY IN SCIENCE TEACHING

In addition to the general competency which any teacher should possess, or possibly within such general competency, teachers of science should possess certain skills and information more specifically concerned with the area and abilities needed in their field. While all teachers need to be skillful in "utilizing proficiently a wide range of materials and methods of instruction" the science teacher needs particularly to be able to use these effectively in connection with the materials and techniques and objectives appropriate to his area. Science teachers also need to have control of more specialized knowledge in this field than do other secondary school teachers.

GENERAL PHASES OF COMPETENCY FOR SCIENCE TEACHERS

In a modern school concerned with the purposes of general education in our democracy, a science teacher cannot be too narrowly specialized, even if he only teaches his own specialty, which is rarely the case, especially with beginning teachers. A physics teacher, for instance, needs to know about important concepts in biology and in chemistry. Since most beginning science teachers will teach general science, the need for a wide background seems obvious. While, of course, a teacher of chemistry or of biology should possess certain knowledge and skill in his particular field, there is important information and abilities concerning all branches of science which any teacher of science should have. This applies to the professional and practical information and skill as well as to the academic.

It is this competency in science and in science-teaching in general that we are considering here. Of course he must have an adequate background in one or more major science areas in addition. Why, again, should we assume that, because a prospective science teacher has certain credits, he is competent and ready to work with boys and girls in even a student teaching situation? Does he really know his subject matter? Does he know about the wealth and variety of possible pupil activities and teaching techniques available in science teaching? Is he aware of the sources of free and low cost supplementary materials and visual aids? Does he know how to operate projectors, to make slides, to improvise the apparatus needed, to construct tests appropriate to specific outcomes, to provide experiences in teaching for thinking, to use and repair needed apparatus, and to plan a unit? He ought to know about and be able to do these and numerous other things before he starts his student teaching—certainly be-

fore he goes out to teach on a regular job. And he can't, or won't, or doesn't learn most of these things after he gets on the job—and why should he be in a teacher preparing institution if he isn't "prepared" to do these beforehand? Why shouldn't we know that he is competent with respect to such things? Why don't we make competency in these the criteria for certification rather than course credits?

If we set up such proficiencies as the "requirements" which prospective teachers have to meet and insisted that such knowledge and skills would have really to be exhibited we would take a first step toward getting competent science teachers. Instead of saying to prospective science teachers who have passed the hurdles for admission to junior standing that they must take certain required courses, only, we might hand them a sheet such as the following:

PREPARATION FOR STUDENT TEACHING

Before assignment to student teaching you should give evidence that you have:

A. *Accumulated a variety of personal teaching aids*—including collections of
1. Supplementary (bulletin board and pamphlet) materials, appropriately mounted or covered, and labeled.
2. Charts, pictures, posters, photographs.
3. Lantern slides, 2 x 2 slides, film slides, films, recordings.
4. Equipment for projects, demonstrations, visual-audio use, and duplicating.

B. *Developed plans and materials for pupil activities*—including
5. An "Inventory-Resource" plan, or a "Source Unit" (or equivalent plan) for two or more units or areas of work.
6. Working plans, or "large unit" plans (with appropriate guides, project-aids, references, evaluation instruments, etc.) for two or more units.
7. A card file (or list) of pupil-Projects.
8. Evaluation instruments—for a variety of outcomes.
9. Bibliographical files of references on
   a. Science topics, areas, projects.
   b. Professional materials.

C. *Passed performance tests in*
10. Use of visual aids.
11. Use of audio aids.
12. Use and repair of key apparatus.
13. Laboratory and shop techniques.
14. Construction of evaluation instruments.
15. Thinking—scientific method.

D. *Passed Information-Achievement Tests* on
16. Books, libraries, professional literature, local and national sources.
17. Government agencies and publications.
18. Professional—subject matter background.
19. Teaching procedures.

E. Kept diary-records (for past year or two) of
20. Reading.
21. Observations, trips, travel, etc.
22. Participation in social and community activities.
23. Experiences with pupils.
24. Experiences and growth in major fields.

Your list would of course be different from this in details. But you would be surprised at what such a list does to the credit-minded junior who has just been concerned with attending class lectures, when you insist that he must show such evidence before student teaching—or else.

This again indicates the kind of evidence with respect to competency which we would expect. It would serve as a guide to the kind of experiences which prospective science teachers would need. It suggests the types of evaluation instruments which would have to be constructed or utilized. Certainly some courses would need to be set up—or some existing ones considerably modified—in which to provide some of the experiences.

But such courses might well become places and times where students made progress toward these proficiencies. In some instances, when students thought that they had achieved proficiency, they could be given an achievement or performance test. In other cases evidence of certain factors in competency would have to be judged by the products which they had produced or accumulated. Courses would be one kind of service agency for getting experiences and guidance.

AUDIO-VISUAL WORKSHOP

Other kinds of service agencies would have to be established. One would be a place where prospective teachers could go to practice operating projectors, to make

slides, to preview films and slides, to work with public address systems, and to make recordings. Perhaps a course in practical audio-visual techniques should be set up in some situations. In others it might be satisfactory to have a sort of visual-audio workshop open to students and under the supervision of a trained assistant. A list of specific skills and knowledge might be set up as a guide to the proficiency desired, and to the kind of evaluation instruments and performance tests to be used in checking. But if hurdles of actual performance were put into effect, we would "turn out" science teachers who could really do things with visual and audio devices, instead of a three-hour credit indicating relative length of exposure.

A SCIENCE-LIBRARY-LABORATORY

Another type of service agency needed is a library-laboratory. Here should be available all sorts of supplementary teaching materials for use in planning units during and preceding student teaching. It would probably include such things as:

- Recent tests, workbooks and laboratory manuals in all science and related fields.
- Reference books—encyclopedias, handbooks, scientific dictionaries, field manuals, covering a variety of subjects.
- Recent supplementary books for both teachers and pupils.
- Periodicals—both science and professional.
- Trade journals.
- Government publications.
- Curriculum guides and course of study material—such as those prepared at the Bureau of Educational Research in Science at Teachers College; the Oregon Curriculum Materials, and recent state and city curriculum materials—as Virginia, Florida, Kansas, Denver, Los Angeles, as well as the P.E.A. materials.
- A file of tests and evaluation instruments.
- A file of bulletin board and pamphlet material for a variety of units.
- Charts and pictures
- Samples of teaching units, source units, guide sheets, exercises.
- A file of pupil-project cards.
- Bibliographies of various sorts.

These would be available for the use of prospective teachers in making their own plans, as well as for taking out to use in connection with student teaching or other experiences.

In addition to these kinds of supplementary and planning materials such a library-laboratory might well include a place where students could develop some materials of their own, either for more or less immediate use in student teaching or for use when on the job. For this there might be available such things as hectographs and mimeographs, paper cutter, paste, brushes, stapler, folders, mounting paper, drawing paper, poster paper, typewriters, drawing instruments, lettering pens. Of course such a science library-laboratory might be part of a general all-subject library-laboratory, if this were practical.

LABORATORY-SHOP

A third type of service agency would be concerned with experiences with science apparatus and tools. Perhaps certain courses in industrial arts could supplement such science laboratory-shop experiences. Possibly a professional "laboratory practicum" for science majors would be appropriate. Certainly it would seem that the experiences provided in using such apparatus, materials and tools should be adapted to the needs of each individual student. A prospective teacher who has had experience as an electrician during his preceding two summers, needs different contacts and activities from one who has worked in a bacteriological laboratory, or from that large majority whose experience with apparatus and tools has been confined to watching a college instructor manipulate demonstrations and to recording the readings on their already-set-up-laboratory experiments in the prepared laboratory manual columns.

Small wonder that so many science teachers resort to a technique of recitations from textbook assignments, when they know as little about practical laboratory and shop devices and are as unskilled in using tools and techniques in repairing, im-

provising and constructing equipment, as most of the science majors now in our teacher preparing institutions.

PRE-STUDENT TEACHING CONTACTS WITH TEACHING

Anyone who has worked with student teachers is aware of the big gap which these teachers feel between theory and practice—and which the high school pupils and the supervising teachers feel also. It always seems to be so new to them—they don't know how "low down" (academically) pupils are; they didn't realize that many junior and senior high school pupils aren't keenly interested in studying science; they didn't seem to realize that one really has to be concerned with other problems than subject matter; they didn't expect that pupils would ask the kind of questions they do; they didn't know that kids were so "different" and that "handling them" was such a job. After a few weeks of student teaching, beginning teachers usually begin to get an idea of the usefulness of some of the academic and professional materials to which they were exposed—and of some other things which they wished that they had had.

Student teaching in the last semester or quarter is too late to really get this new vision and realization of one's limitations, and to do what needs to be done about it. Prospective teachers need to have contact with high school pupils and teaching situations before this valuable culminating experience in order to get the maximum from it. They need to participate in at least a minor way with pupils in a school situation so as to see what kind of animals they really are going to have to work with, and what some of the teaching problems actually are.

Even though prospective teachers get some contacts in this direction through group and individual visitation and observation in connection with general professional courses, they need to have some first-hand responsibility and experience with the problems of the area in which they are going to be teaching. They need to have this more than for a week or two, if they are to make much progress toward many of the phases in competency which we have been stressing. This doesn't mean that they need to do actual teaching during this pre-student teaching period, but that they deal with boys and girls and with some of the materials and procedures and problems of science teaching.

Probably such experiences should be in units of rather short periods of about three or four weeks at a time in one situation, shifting to different situations so that a variety of experiences and contacts with different levels and types of teaching problems are obtained. Prospective teachers could work with regular teachers—be sort of assistants. Three or four could even work in a single class, with proper planning.

Among the kinds of experiences which can be provided either as part of courses at about the late sophomore or junior year level, or as extra-course experiences are: (1) Setting up demonstrations; (2) Helping in the laboratory; (3) Preparing quizzes; (4) Correcting quizzes and "home-work" papers; (5) Hectographing or mimeographing; (6) Making home-made slies; (7) Operating projectors; (8) Gathing reference materials; (9) Preparing bulletin board materials; (10) Helping pupils with projects; (12) "Tutoring" advanced or retarded individuals or small groups; (12) Helping with sciene clubs; (13) Preparing exhibits; (14) Working out guide sheets; (15) Repairing and improvising laboratory equipment; (16) Working up "exercises" in scientific thinking; (17) Storing apparatus; (18) Preparing inventories; (19) Giving a "special report" to the class.

CONCLUSION

All of these—courses and services agencies and participation—are, then, the vehicles which provide the opportunities and experiences for prospective teachers to

achieve science teaching competency. They are not the ends in themselves, but are some of the means toward the goal of competent science teachers. Hurdles, as suggested previously, of one sort or another would need to be established to determine "how we're doing" in making progress toward the various phases or factors in competency. Evidence of progress, or lack of it, would be obtainable all along the line, and students would need to be counselled accordingly. A cumulative record of achievements, of performance tests, of experiences, of anecdotal records, of reading, of materials and plans accumulated or constructed, of changing points of view and attitudes, should provide both prospective teachers and advisors with evidence of growth with respect to such competency. One would be ready to go out with a certificate to teach when he had given such evidence rather than when he had simply served his time and accumulated a certain number of credit hours.

Such a plan should mean that fewer poorly prepared science teachers would be "turned loose" from our institutions; and because prospects would really have to "show their stuff" before they would be certified to teach, should help to put science teaching on a real professional level.

TYPES OF THOUGHT QUESTIONS IN TEXTBOOKS OF SCIENCE

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Although many writers have discussed the importance of skillful questioning as a part of effective teaching, relatively few studies reported deal with types of questions and with the frequencies with which these types are used in the classroom and in instructional materials. The earliest extensive investigation of questions was that of Stevens [1] who analyzed about two thousand questions asked in classes from the seventh through the twelfth grade, which she had secured from stenographic reports of 20 class periods, from 100 random observations of entire class periods in various subjects, and from a series of 10 observations in each of which she observed the same group of pupils through all its class periods during an entire day. Although she was concerned primarily with the numbers of questions which the teachers asked of pupils, nevertheless she included in her report a section dealing with "quality" of questions, in which she made a distinction between questions that require memory only and those that stimulated reflective thinking. She found that this latter type constituted between 10 and 15 per cent of the entire list analyzed.

Later Monroe and Carter [2] identified 20 types of thought questions which teachers may profitably use. Because the published report of the investigation does not clearly indicate the teachnique used in determining the types, one of the investigators [3] of the problem here reported sent a letter of inquiry to Dr. Monroe, who made this reply:

[1] Romiett Stevens. *The Question as a Measure of Efficiency in Instruction.* Teachers College Contribution to Education, No. 48. New York: Teachers College, Columbia University, 1912.

[2] Walter S. Monroe and Ralph E. Carter. *The Use of Different Types of Thought Questions in Secondary Schools and Their Relative Difficulty.* University of Illinois Bureau of Educational Research Bulletin No. 14. Urbana: University of Illinois, 1923.

[3] Charles Weinstock. *An Analysis of the Types of Thought Questions Found in Workbooks for General Science.* Unpublished Master's Thesis, University of Michigan, 1940. P. 3.

The list of types of thought questions . . . was derived mainly by Mr. Carter . . . his procedure was largely empyrical and the list was developed over a period of years in connection with courses which he taught. Preliminary formulations of his list were submitted to various groups and to some individuals for criticism. On the basis of suggestions received, revisions were made until a reasonably acceptable list was evolved.

"I do not recall that Mr. Carter published any account of his method."

The importance and usefulness of the Monroe and Carter list is manifest in the fact that it was subsequently employed in such investigations of questions as those by Cunningham and Boyd.

Cunningham [4] analyzed the questions found in 7 textbooks and 3 workbooks of general science. During the process of this investigation, Cunningham added two types of questions to the Monroe and Carter list. He classified a total of 9,038 questions, putting them into the 22 categories. Boyd [5] analyzed 1042 questions appearing in 4 textbooks of hygiene.

A list of 21 types of thought questions, which includes most of those in the Monroe-and-Carter list, was later supplied by Wesley,[6] but the list was accompanied by no discussion, which would indicate that the question types were determined through the employment of investigational techniques.

An aspect of teaching so important as the stimulation of reflective thinking through the use of through questions would seem to be of sufficient weight to justify further investigation of question types and of their use in textbooks and other media of instruction. The account that follows is the report of such an investigation:

[4] Harry A. Cunningham. "Types of Thought Questions in General Science Textbooks and Laboratory Manuals." *General Science Quarterly*, IX (January, 1925), 91–95.

[5] John E. Boyd. "What Types Questions?" *Body and Mind*, XXVII (December, 1930), 237–240.

[6] Edgar Bruce Wesley. *Teaching in the Social Studies.* New York: D. C. Heath and Company, 1937. Pp. 485–486.

PART I. DETERMINING THE TYPES OF THOUGHT QUESTIONS

The purpose of the first part of the investigation was to determine types of thought questions suitable for use in the teaching of high-school science.

Six investigators,[7] all teachers of science in Michigan or Ohio high schools engaged in this study during an entire school year, while enrolled in the author's seminar in the teaching of science. Their procedure was to work as a group in formulating and defining the procedures to be followed, then to apply these techniques individually, and later, again as a group, to review, discuss, and modify the various steps in the light of the experience gained from their individual applications of the techniques. By thus alternating extended group conferences with individual applications of the results of these conferences, the group kept their techniques in a constant process of modification and refinement until finally they succeeded in fashioning procedures which enabled them to secure results which they deemed acceptable.

The types of questions defined by Cunningham were made the basic list and were

[7] Under Part I is presented a summary of the first unit of each of six unpublished master's theses completed under the author's direction at the University of Michigan in 1940 and 1941:

Kenneth George Crothers. *Types of Thought Questions Found in Five High-School Textbooks of Chemistry.*

Rheingold F. Hollitz. *An Analysis of Types of Questions Found in Six Currently-Used General-Science Textbooks.*

Loy W. Rusie. *Types of Thought Questions Found in Workbooks in High-School Biology.*

Vinson M. Weber. *An Analysis of Types of Questions Found in Six Currently-Used Biology Textbooks.*

Charles Weinstock. *Op. cit.*

Lauren Gale Woodby. *An Investigation of Types of Questions Occurring in Six High-School Textbooks of Physics.*

Under Part II is presented a summary of the second and final unit of each of the six theses of the preceding list together with the corresponding unit of an additional thesis completed later: John H. Righi, *An Analysis of the Types of Non-Objective Questions Found in Seven Textbooks of Physics.*

supplemented with additional types from the list of Munroe and Carter and that of Wesley. Thirty-six types of questions were thus obtained. This list was reduced through extensive group discussion to include only 21 types which were believed by the investigators to be unique and mutually exclusive. The investigators together then selected for classification 100 questions taken at random from various textbooks and workbooks of physics, chemistry, biology, and general science.

They decided that each part of every question that was composed of more than one part was to be classified as if it were a separate question. An example of such a question is, "What are latitude and longitude, and how are they used to determine the locations of points on the surface of the earth?" They further decided that group agreement with respect to the classification of any question should be considered to have been reached, provided that 4 of the 6 investigators gave the question the same type designation. They then proceeded to classify the hundred questions independently in terms of the list of 21 question types, which they had formulated.

A subsequent comparison of the individual classifications revealed that all six investigators agreed on the classifications of 11 questions, that three agreed with respect to the types of 29, and that fewer than three agreed with respect to 20. The group decided that these results were unsatisfactory, and that accordingly further revision, refinement, and definition of the question types were necessary. Accordingly, they next experimented with a scheme of classification in outline form with four major types of questions, each embracing one or many sub-types. A subsequent trial of this plan for classifying questions, however, proved the list of question types to be so unsatisfactory that the investigators returned to the task of revising their original list. Putting into effect the results of experience gained from their previous use of the list, they reduced the 21 types to 16 by combining several of the categories and reorganizing others in such a way as to eliminate possibly overlapping types and those involving too-finely-drawn distinctions. They deemed that such loss as might result with respect to refinement in classification would be compensated for in the increased objectivity of classification. To insure agreement with respect to the exact nature of each type, the group together selected or invented examples which they unanimously agreed were respectively typical. They agreed also to consider any sentence or phrase to be a "question" if it called for a direct verbal response. The question types and examples follow:

1. Comparison and contrast.
   - What are the differences between weather and climate?
   - In parallel columns compare the eye and a camera, noting all similarities and differences.
2. Decision for or against.
   - Will air serve as well as oil in a hydraulic press? Explain.
   - Which system of measurement is more logical to use if you have learned both equally well? Justify your answer.
3. Application of facts or principles already learned in new situations.
   - Suggest ways of correcting annoying reverberations in a hall or church.
   - A glass stopper is stuck in a bottle and cannot be removed by twisting or tapping it. Suggest a way of loosening it.
4. Classification.
   - To what class of lever does the wheelbarrow belong?
   - From your observation of the number of legs this specimen has, to what group of animals do you think it belongs?
5. Relationships involving cause and effect.
   - What is the relation between efficiency and friction of a machine?
   - What would be the result of washing a piece of cake down your throat without chewing it?
6. Example or illustration.
   - Name a parasite.
   - Describe a case that you have actually witnessed where friction proved to be a disadvantage.
7. Statement of author's aim or purpose in the selection or arrangement of materials.
   - Why are hydrogen and oxygen studied before water?
   - Why do you think the main divisions of plant and animal life are presented early in the book?

8. Criticism of the adequacy, correctness, or relevancy of a situation, statement or diagram.
   - What was your main source of error?
   - From your observation, what criticism should you offer of the posture diagram?
9. Inference from data.
   - From the facts presented what do you think will be likely to happen in Niagara Falls during the next million years or so?
   - What do you conclude concerning the relative rate of heat radiation from a dull and from a shiny object?
10. Discussion.
    - Present arguments for and against the introduction of the metric system in place of the English system in this country.
    - Discuss photosynthesis.
11. Outline.
    - Outline a method for removing tarnish from copper.
    - List in order the various blood vessels through which the blood would flow in circulating from your toe to your heart and back.
12. Explanation or definition.
    - What is meant by "persistence of vision"?
    - Tell in your own words what erosion is.
13. Simple recall.
    - What is the chemical formula for water?
    - How many legs has an insect?
14. Summary.
    - What characteristics do all satellites of the sun have in common?
    - What facts can you state about lines of force?
15. Observation.
    - Where does the diagram show most of the planetoids to be?
    - What are the characteristics of the oxygen which has just been made by heating potassium chlorate and manganese dioxide?
16. Formulation of new questions.
    - What questions occurred to you while performing this experiment?
    - Write three additional questions based on this experiment, that you would like to have answered.

In formulating and discussing this list of question types, the investigators recognized the obvious fact that a question out of context might logically be classified as belonging to any one of several types because there would be no way of knowing what explanation or discussion had preceded the question. For example, any question would be one of simple recall if the answer to that particular question had previously been stated in the book or in the class discussion. They noted especially the difficulties involved in distinguishing between types 3, 6, and 13. In order to reduce as much as possible the lack of agreement likely to result from independent attempts to distinguish between these types, the group agreed to consider a question to be one of simple recall only if it obviously could be of no other type; and to consider a question to be one of "application in a new situation" only after other possibilities had been considered and discarded.

The six investigators then proceeded individually to classify the list of one hundred questions already assembled, into the sixteen types in their finally revised list.

When later they compared results, it was found that there was agreement by all six investigators with respect to the classifications of 28 of the hundred questions; that there was an agreement by five of 27 questions; an agreement by four on 20; and one of three investigators with respect to 19 questions. Thus there were only six of 100 questions on the classification of which fewer than three of the six investigators agreed. Only two of the 16 question types, Nos. 7 (statement of author's aim) and 11 (Outline) were not designated by any of the investigators as being illustrated by at least one of the hundred questions.

On the basis of these results the investigators tentatively concluded that their scheme of classifying questions was sufficiently valid, objective, and satisfactory to justify its use in classifying the questions found in textbooks. As a check, however, they used the list in individually classifying 50 additional questions chosen at random from textbooks of science. The results in this case showed an agreement somewhat less close than that which has resulted in the classifying of the preceding list of one hundred questions: All six agreed with respect to 8 questions; five were in agreement with respect to 13; four, with respect to 11;

half the group, or three, with respect to another 13; and fewer than half were in agreement with respect to only 5 questions.

As a further check on the suitability of the question list as an instrument for classifying questions, the investigators selected from the original list of one hundred questions, 25 which they thought to be representative of the entire list. These were typed and then were given, along with the same list of 16 question types and their accompanying examples as was used by the six investigators, to four experienced teachers of science, who were asked to classify the questions. The classifications by these four teachers were compared with those of the same questions by the six investigators. With respect to only three questions out of the twenty-five did the judgments of half (2) of the teacher group fail to agree as to type with the judgments of at least half (3) of the investigator group.

Aside from the consideration of the validity and the practical usefulness of the list of question types there remained the question of its reliability as an instrument for classifying questions. To determine the reliability each investigator selected 50 questions at random from the textbooks in which he intended later to classify the thought questions. These he classified in terms of the 16 types. Two months later, without having in the interim examined either the questions or the list of question types he reclassified the 50 questions. The range of agreement of the six investigators in their respective two analyses was from 86 to 93 questions.

From the results of the three separate classifications of questions as to type, and of the investigation to determine the reliability of the list, the investigators concluded that the list of 16 types of thought questions constituted a satisfactory instrument for use in classifying the thought questions in textbooks and workbooks of science.

PART II. CLASSIFYING THOUGHT QUESTIONS

The purpose of this part of the investigation was to determine the types of thought questions found in textbooks and workbooks of high-school science and to determine also the relative frequencies with which these various types were used in the books.

Each of the six investigators who collaborated in Unit I, together with another who used the list of question types determined by the six, classified the thought questions appearing in recently-published textbooks or workbooks in his field of specialization. All questions appearing in the books were classified except short-answer questions included as tests at the ends of sections, chapters, or units, and questions designed for preview, or inventory, purposes at the beginnings of units or chapters. In order to distinguish more effectively among the types of questions which had caused the major difficulties in the previous analyses described in Part I, namely types 3, 6, and 13, each investigator carefully read each section of the text or workbook before classifying the questions belonging to that section.

Tables I, II, and III show the results of these seven analyses.

Table I indicates that in all, 44,722 thought questions in 43 books representing the four common fields of high-school science were analyzed and classified.

It will be noted in Table I that the mean numbers of thought questions per textbook of general science, physics, and biology did not vary greatly, but that the mean number per textbook of chemistry was practically double that of the books in each of the other three fields. The mean numbers of questions per workbook in general science and biology were found to be more than double the mean numbers per textbook in these respective subjects.

The ranges in numbers of thought questions per book in the various fields were great. One textbook of general science had

TABLE I

THE NUMBERS OF THOUGHT QUESTIONS IN THIRTY TEXTBOOKS AND THIRTEEN WORKBOOKS OF HIGH-SCHOOL SCIENCE

Books Analyzed	Numbers of Books Analyzed	Total Numbers of Questions	Mean Numbers per Book	Range in Numbers per Book
Textbooks				
General Science	6	4553	758.4	176–1550
Biology	6	3843	640.5	399–909
Chemistry	5	6286	1257.2	828–1729
* Physics	13	7919	609.1	288–1245
Workbooks				
General Science	7	12847	1835.3	937–2802
Biology	6	9274	1545.7	1027–2312

* The data of the two analyses of textbooks of physics are here combined.

more than seven times as many thought questions as another, and in no case did the book with the smallest number of thought questions in a group have half as many questions as the book of that group having the greatest number.

Table II reveals that the types of questions most frequently found in the thirty textbooks analyzed are those demanding mere recall of facts, previously stated; those requiring the pupil to give an explanation or a definition; and those involv-

TABLE II

NUMBERS AND PERCENTAGES OF THOUGHT QUESTIONS OF EACH TYPE FOUND IN THE VARIOUS GROUPS OF TEXTBOOKS AND WORKBOOKS

Type of Question	General Science Textbooks		Biology Textbooks		Chemistry Textbooks		* Physics Textbooks		General Science Workbooks		Biology Workbooks	
	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Explanation (12)	1,081	23.7	185	4.8	1,126	17.9	1,617	20.3	918	7.2	1,292	14.0
Recall (13)	975	21.4	788	20.5	1,997	31.8	2,024	25.6	4,103	31.9	3,432	37.0
Decision (2)	631	13.9	243	6.3	233	3.8	582	7.4	696	5.4	395	4.3
Discussion (10)	608	13.3	98	2.6	297	4.7	140	1.8	35	.3	64	.7
Relationship (5)	579	12.7	748	19.5	285	4.5	1,277	16.1	1,288	10.0	200	2.2
Observation (15)	206	4.5	265	6.9	68	1.0	113	1.4	2,346	18.3	1,935	20.9
Comparison (1)	143	3.1	261	6.8	496	7.9	512	6.4	534	4.2	283	3.1
Application (3)	110	2.4	466	12.1	574	9.1	750	9.5	573	4.5	83	.9
Example (6)	94	2.0	260	6.7	496	7.9	364	4.6	634	5.0	132	1.4
Classification (4)	64	1.4	128	3.3	90	1.4	123	1.5	511	4.0	138	1.5
Inference (9)	47	1.0	113	3.0	8	.1	318	3.9	1,022	8.0	1,192	12.9
Outline (11)	15	0.3	30	.8	82	1.3	34	.4	13	.1	5	.1
Summary (14)	....	...	144	3.7	3	.0	19	.2	85	.7	110	1.2
New Questions (16)	....	...	3	.1	5	.0	7	.1	65	.5	....	....
Aim (7)	....	...	20	.5	526	8.3	3	.0	6	.1	1	.0
Criticism (8)	....	...	64	1.7	....	...	36	.5	18	.1	12	.1
Unclassified	....	...	27	.7	....	...	....	...	.....	....	....	....
Totals	4,553	99.7	3,843	100.0	6,286	99.7	7,919	99.7	12,847	100.3	9,274	100.3

* The data of the two analyses of textbooks of physics are here combined.

ing relationships. Together these three types constitute more than half the questions in these books. Other types well represented in these textbooks are those involving application of fact or principle in a new situation, decision, discussion, observation, comparison, and example.

The chief differences between the proportions of the various types of questions found in the textbooks and in the workbooks of general science and biology consist in the considerably greater percentages in the workbooks, of questions involving observations and recall. The first of these differences would be expected because of the large proportion of directions for experimentation which workbooks contain; the second is probably explainable on the grounds that the modern workbook contains study-guide questions, together with a wide variety of directions for other activities which are based more or less directly upon the text for which the workbook is written.

Such characteristic differences as may exist in the question types most commonly used in workbooks and textbooks and indeed, between those in textbooks for different fields of science, cannot be inferred with assurance from the data here presented, but must await definition from the results of other extensive investigations. Such differences, however, are relatively unimportant when compared with the fact that a considerable number of valuable types of thought questions were employed only sporadically or not at all by the authors of these textbooks and workbooks analyzed. Those involving classification, the drawing of inferences, the construction of outlines, and making of summaries, the formulation of new questions, the questions involving the author's aim, and those requiring the criticism of an incorrect or an inaccurate statement have much smaller representations in these books than their potential values warrant.

Table III furnished further evidence that several valuable types of thought questions are infrequently introduced into textbooks and workbooks of high-school science. In more than half the textbooks and two-third

TABLE III

THE NUMBERS OF TEXTBOOKS AND WORKBOOKS IN WHICH THE INDICATED NUMBERS OF QUESTION TYPES WERE EACH REPRESENTED BY AT LEAST ONE PER CENT OF THE TOTAL NUMBER OF QUESTIONS

Books Analyzed and Field Represented	Number of Question Types									
	16	15	14	13	12	11	10	9	8	7
Textbooks										
*General Science					1	1	1			3
Biology			1		1	2	1	1		
Physics						4	5	2		2
Chemistry					1	2	1	1		
Workbooks										
General Science					1	3	2	1		
Biology						1	2		2	1

*Table III is read thus: In one of the six textbooks of general science 12 types of questions were each represented by at least 1 per cent of all the thought questions in the book; in another text, 11 types were so represented; in a third, 10 types; and in each of the remaining three books not more than 7 types of thought questions were each represented by as many as 1 per cent of the total number of questions in the book.

of the workbooks, only ten or eleven types of thought questions appear, each in sufficient numbers to constitute at least 1 per cent of the total number of questions in the book.

Evidence not shown in any of the tables reveals that in only one of the thirty textbooks and one of the thirteen workbooks were all sixteen types of questions represented and nearly two-thirds of these textbooks and workbooks contained questions of thirteen or fewer types. Three textbooks contained fewer than ten types of questions.

CONCLUSIONS

The evidence here presented would seem to justify the conclusion that authors of textbooks and workbooks in the various fields of high-school science are failing to make sufficient use in their books of a considerable number of valuable types of questions which stimulate reflective thinking. A comparison of these findings with those of Cunningham indicate that, with respect to general science at least, modern authors make a somewhat wider use of various types of thought questions than did those of about two decades ago; nevertheless such improvement in the direction of diversified questioning is too small to indicate an awareness of the potential value of including in materials of instruction all types of thought questions.

A SYNTHESIS OF THE RESULTS OF TWELVE CURRICULAR STUDIES IN THE FIELD OF SCIENCE EDUCATION--II *

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The method of assigning relative values to principles within each contributing study is based upon the assumption that each principle to which items from a given study have been assigned should have at least as high a relative value in that study as the highest relative value carried by any informational item assigned to it from that study. On the basis of this assumption, each principle was given a numerical value in each source, except Number IX (Partridge and Harap), equal to the numerical value of the highest ranking item assigned to it from that source.

Each principle to which items from the Partridge and Harap study had been assigned was given a numerical value in that source equal to the total number of different commodities associated with all scientific terms assigned to it. The validity of this method of assigning values to principles in this source is based upon the assumption that the values so assigned represent one measure of the relative values of the principles as they are applied in purchasing, understanding, and using commodities common to modern life.

The last column in Table I shows the method of assigning values to principles in each of the eleven contributing studies.

The procedures which have been described resulted in the assignment of relative values to a number of principles of physical science in each of eleven different studies or sections of studies. Table II indicates that the number of principles assigned values within each contributing study varied from a minimum of 53 in the case of the second part of the Robertson study to a maximum of 211 in the Curtis study. The procedure followed in an earlier phase of this investigation resulted in the assignment of relative values to 246 principles.*

* *Concluded from February issue, page 40.*

* Wise, *op. cit.*

TABLE II

SUMMARY OF ASSIGNMENT OF INFORMATIONAL ITEMS TO PRINCIPLES *

Contributing Study	Number of Items in Field of Physical Science	Number of Items Usable in the Study	Number of Assignments of Items	Number of Principles to Which Items Were Assigned †
Craig No. 1	46	46	225	143
Craig No. 2	59	59	287	150
Curtis	1,300	754	1,301	211
Davis	91	91	312	147
Heiss	353	337	704	164
Muller and Weiser	1,150	957	1,598	204
Nelson	155	87	172	88
Newland	893	819	1,109	191
Partridge and Harap	269	269	419	108
Robertson No. 1	193	193	198	158
Robertson No. 2	58	58	58	53
Total	4,567	3,670	6,383	

* This table should be interpreted as follows: The first section of Craig's Dissertation utilized in this investigation yielded forty-six items which belonged in the field of physical science. All of these items were considered to have value in that their study would contribute to the development of an understanding of principles of physical science. The forty-six items were given a total of 225 assignments distributed among 143 different principles of physical science.

† The total number of principles to which items from any contributing study were assigned was 260.

In order to determine the total number of different principles to which relative values had been assigned in any one of these twelve studies, the principles which received values in the earlier part of the investigator's study were checked against those receiving values in any one of the eleven contributing studies. This procedure revealed the fact that relative values in at least one study had been assigned to 264 different principles.

It is, therefore, assumed that, to the extent to which the techniques which have been employed in this investigation are valid, each of these 264 principles has some value for general education. The steps in procedure which have been employed in order to determine the final relative value of each of these 264 principles are as follows:

I. The assignment of ranks within each study to each of the 264 principles.
II. The determination of the weight of twelve contributing sources of data.
III. The determination of the weighted ranks of the 264 principles within each source.
IV. The determination of the aggregate value of each of the 264 principles.
V. The determination of the final relative values of the 264 principles.

Each of these steps is described in detail in the following paragraphs.

The validity of the method employed in assigning ranks to principles is based upon the following assumptions:

A. That each of the twelve studies which together constitute the sources employed in this section of the present investigation is of sufficient scope to include material from the respective fields of physics, chemistry, astronomy, and geology, which is appropriate for general education.
B. That the 264 principles to which either applications or informational items from one or more of these twelve studies were assigned are also representative of the fields of physics, chemistry, astronomy, and geology, and are appropriate goals of a science curriculum intended for general education.
C. That, if the preceding assumptions are valid, the failure of any one of the twelve sources to contribute material leading to the assignment of relative values, within that source, to all of the 264 principles is attributable to one or more of the following reasons: (1) the sampling of materials from which the data were secured was not sufficiently representative to

include items which could be assigned to each of the 264 principles in accordance with the techniques employed in this investigation; or (2) the method employed in the investigation did not reveal all of the items which might have been obtained from the sources utilized; or (3) the report of the investigation was so limited as to exclude some of the items which the investigation may have revealed.

D. That the principles to which relative values have been assigned in each source were the most important within that source.

Under these assumptions, it was, therefore, deemed defensible to conclude that those principles which were assigned relative values within a source should be given the highest ranks within that source, according to their numerical or relative values, while the remainder of the 264 principles should all be considered as having the same value insofar as that source is concerned. It was apparent also that the most defensible rank to assign each of these principles would be the average of the ranks remaining after the principles carrying values in that source had all been assigned ranks, from 264 downward. This method was employed in assigning ranks to the 264 principles within each of the twelve source studies. For example, the investigator's original study resulted in the assignment of relative values to 246 of the 264 principles but, due presumably to one or more of the limiting factors previously discussed, it did not reveal relative values for the remaining eighteen principles. In this study, therefore, the 246 principles were assigned ranks, according to their relative values, from 264 downward including nineteen. each of the eighteen remaining principles was then assigned a rank equal to the average of the eighteen remaining ranks, or 9.5. To illustrate further, the data included in the second section of the Robertson source (Contributing Study Number XI) resulted in the assignment of relative values within that study to but fifty-three of the 264 principles. Accordingly, these fifty-three principles were assigned ranks in the order of their relative values from 264 downward, including 212, while the remaining 211 principles were assigned the average of the remaining 211 ranks, or 106.

The twelve studies which were utilized as contributing sources of data in this section of the investigation obviously could not be thought of as having equal weight in determining final relative values for the principles of physical science. Each study differed from every other study with respect to one or more of such factors as scope, research technique employed, type of data revealed, degree of comprehensiveness, and abjectivity. In order, therefore, to determine the weight which should be assigned to each source, it was decided to utilize the judgment of experts in the field of science education.

An abstract of each of the twelve source studies was prepared as a means of securing expert judgments. In preparing these abstracts, the investigator attempted to describe as accurately as possible the scope, research method, and statistical technique employed in each study. While the varying nature of the studies made it impossible to devote equal space to each study, each abstract was as concisely written as possible without sacrificing elements considered to be essential.

In order to provide a common basis for the weighting of studies, it was decided to assign the investigator's own source study an arbitrary value of fifteen points and to ask that each evaluator assign each of the remaining source studies a weight above or below fifteen points according to his opinion of its worth in the synthesis as compared to the worth of the investigator's study.

Following the preparation of the abstracts, a letter requesting cooperation in assigning relative weights to the twelve source studies was sent to sixteen persons all of whom are, or have been, identified with work in science education in either a college, university, or large public school system. Eleven of these persons are also listed as associate and departmental editors of SCIENCE EDUCATION and most of them

are members of the National Association for Research in Science Teaching. Fourteen of the persons to whom the initial letter was sent indicated their willingness to act as evaluators. These persons were each supplied with copies of the abstracts and with a sheet ruled in a form suitable for recording relative weights assigned to each study compared to the fifteen points arbitrarily assigned to the investigator's study.

Ten of the evalutors assigned weights to each of the source studies and returned their evaluations in time for use in the next step of this investigation. The investigator also personally assigned weights to each of the twelve studies. However, in order to prevent the returns of the cooperating evaluators from influencing his judgment, his evaluation was prepared before any of the returns were received.

The median number of points assigned to each study by the eleven evaluators was used as the weight of the study. These medians, together with the range of weights assigned to each study, are shown in Table III.

TABLE III

MEDIAN WEIGHTS AND RANGE OF WEIGHTS ASSIGNED TO THE TWELVE SOURCE STUDIES BY THE ELEVEN EVALUATORS

Source of Data	Median	Range
Craig No. 1	10	5–25
Craig No. 2	10	5–22
Curtis	15	8–20
Davis	7	0–10
Heiss	8	0–15
Muller and Weiser	10	5–15
Nelson	8	1–12
Newland	10	3–15
Partridge and Harap	8	5–18
Robertson No. 1	12	2–18
Robertson No. 2	10	4–18
Wise	15	15–15

The next step in procedure involved the determination of the weighted ranks of the 264 principles which had been assigned ranks within each source. This was accomplished by multiplying the rank of each principle in each source by the median of the weights assigned to that source by the eleven evaluators. This method of determining weighted ranks is illustrated in Table IV.

TABLE IV

THE METHOD OF DETERMINING WEIGHTED RANKS *

Principle	Rank in Craig No. 1 Study	Median Weight Assigned Craig No. 1 Study	Weighted Rank in Craig No. 1 Study
1. Energy can never be created or destroyed; it can be changed from one form to another with exact equivalence.	245	10	2,450
2. The work obtained from a simple machine is always equal to the work put into it less the work expended in overcoming friction.	143.5	10	1,435
3. When there is a gain in mechanical advantage by using a simple machine, there is a loss in speed and *vice versa*.	143.5	10	1,435
4. In the inclined plane, weight times height equals acting force times length, providing friction is neglected and the force is parallel to the plane.	143.5	10	1,435
5. In the lever the force times its distance from the fulcrum equals the weight times its distance from the fulcrum.	143.5	10	1,435
6. When forces act in the same direction, the resultant is their algebraic sum.	61	10	610

* This table is intended merely to show the method employed in determining the weighted rank of each principle within each source. It therefore, shows data from only one of the twelve source studies and for only six of the 264 principles.

The table should be interpreted thus: Principle No. 1 was assigned a rank of 245 in the first section of the Craig study. The median of the weights assigned to this contributing source by the eleven evaluators was 10. The Weighted Rank of this principle in the Craig No. 1 source was, therefore, computed by multiplying its Rank by the median weight of the source ($245 \times 10 = 2{,}450$).

The aggregate value of each principle was determined by calculating the sum of the weighted ranks of each principle in all sources. In order to transform these aggregate values to a more convenient scale, the aggregate value of each principle was reduced to the percentage of the maximum possible value which a principle might have had, had it been assigned the highest rank in each of the source studies. The formula utilized in making this transformation follows:

$P=\frac{100\,A}{N\,W}$, where P equals the percentage of maximum value, or in other words the final relative value of a principle, A equals the aggregate value of a principle, N the total number of principles (264), and W the sum of the median weights assigned to all source studies (123). Table V shows the method employed in determining aggregate values and of tabulating final relative values of principles.

FINDINGS

The one hundred principles which were found to rank highest in importance for general education as a result of techniques employed in this investigation follow in the order of decreasing value:

1. Solids are liquefied and liquids are vaporized by heat; the amount of heat used in this process, for a given mass and a given substance, is specific and equals that given off in the reverse process.
2. Every pure sample of any substance, whether simple or compound, under the same conditions will show the same physical properties and the same chemical behavior.
3. The rate of evaporation of a liquid varies with temperature, area of exposed surface and saturation and circulation of the gas in contact with the liquid.
4. A fluid has a tendency to move from a region of higher pressure to one of lower pressure; the greater the difference, the faster the movement.
5. When there is a gain in mechanical advantage by using a simple machine, there is a loss in speed and *vice versa*.
6. Oxidation and reduction occur simultaneously and are quantitatively equal.
7. Oxidation always involves the removal or sharing of electrons from the element oxidized while the reduction always adds or shares with the element reduced.
8. When waves strike an object, they may either be absorbed, transmitted, or reflected.
9. Any two bodies attract one another with a force which is directly proportional to the attracting masses and inversely proportional to the square of the distance between their centers of mass.
10. The principal cause of wind and weather changes is the unequal heating of different portions of the earth's surface by the sun, thus all winds are convection currents caused by unequal heating of different portions of the earth's atmosphere, and they blow from places of high atmospheric pressure to places of low atmospheric pressure.
11. An electrical charge in motion produces a magnetic field about the conductor, its direction being tangenital to any circle drawn about the conductor in a plane perpendicular to it.
12. The pressure in a fluid in the open is equal to the weight of the fluid above a unit area including the point at which the pressure is taken; it therefore varies as the depth and average density of the fluid.
13. Movements of all bodies in the solar system are due to gravitational attraction and inertia.
14. The materials forming one or more substances, without ceasing to exist, may be changed into one or more new and measurably different substances.
15. The amount of heat produced by an electric current is proportional to the resistance, the square of the current and the time of flow.
16. When two bodies of different temperature are in contact, there is a continuous transference of heat energy, the rate of which is directly proportional to the difference of temperature.
17. Energy can never be created or destroyed; it can be changed from one form to another with exact equivalence.
18. An electric current will flow in the external circuit when two metals of unlike chemical activity are acted upon by a conducting solution, the more active metal being charged negatively.
19. When light rays pass obliquely from a rare to a more dense medium, they are bent or refracted toward the normal and when they pass obliquely from a dense to a rarer medium, they are bent away from the normal.
20. Sound is produced by vibrating matter and is transmitted by matter.
21. Electrons will always flow from one point to another along a conductor if this transfer releases energy.
22. Most bodies expand on heating and contract on cooling; the amount of change depending upon the change in temperature.
23. Like electrical charges repel and unlike electrical charges attract.

TABLE V

THE METHOD OF CALCULATING AGGREGATE AND FINAL RELATIVE VALUES OF PRINCIPLES

	Weighted Ranks												Aggregate Value †	Final Relative Value ‡
	A*	B	C	D	E	F	G	H	I	J	K	L		
Principles of Physics														
1. Energy can never be created or destroyed; it can be changed from one form to another with exact equivalence.	2,450	1,660	1,882	1,494	1,776	1,545	2,076	1,550	1,388	3,102	2,425	3,172	24,430	75.2
2. The work obtained from a simple machine is always equal to the work put into it less the work expended in overcoming friction.	1,435	1,660	3,855	1,494	1,776	2,120	708	1,835	628	2,844	2,555	1,290	22,200	68.4
3. When there is a gain in mechanical advantage by using a simple machine, there is a loss in speed, and *vice versa*.	1,435	1,660	3,090	1,494	1,776	2,120	708	1,890	1,388	6,420	1,060	3,427	26,468	81.5
4. In the inclined plane, weight times height equals acting force times length, providing friction is neglected and the force is parallel to the plane.	1,435	1,660	2,295	1,046	1,776	2,120	708	765	628	1,794	1,060	1,905	17,192	52.9

* The letters A, B, C, etc., signify respectively the Craig No. 1, Craig No. 2, Curtis, Davis, Heiss, Muller and Weiser, Nelson, Newland, Partridge and Harap, Robertson No. 1, Robertson No. 2, and Wise studies.

† The aggregate value of each principle is equal to the sum of the weighted ranks assigned to that principle in each study.

‡ The Final Relative value of each principle is expressed as the percentage of the highest possible value which a principle might have had, had it received the highest rank in each one of the twelve studies.

24. If a beam of light falls upon an irregular surface, the rays of light are scattered in all directions.
25. Heat is liberated when a gas is compressed, and is absorbed when a gas expands.
26. If the same pressure is maintained, the volume of a gas is varied directly as the absolute temperature.
27. The natural movements of air, water and solids on the earth are due chiefly to gravity plus rotation of the earth.
28. All substances are made up of small particles called molecules which are alike in the same substance (except for variations in molecular weight due to isotopes) but different in different substances.
29. Heat is transferred by convection in currents of gases or liquids the rate of transfer decreasing with an increase in the viscosity of the circulating fluid.
30. Parallel light rays may be converged or focused by convex lenses or concave mirrors; diverged by concave lenses or convex mirrors.
31. Whenever an opaque object intercepts radiant energy traveling in a particular direction, a shadow is cast behind the object.
32. The higher the temperature of the air, the greater the amount of moisture required to saturate it.
33. The dispersion of white light into a spectrum by a prism is caused by unequal refraction of the different wave lengths of light.
34. Elements and compounds to which the cells of living organisms react specifically produce physiological effects.
35. An e.m.f. is induced in a circuit whenever there is a change in the number of the lines of magnetic force passing through the circuit.
36. A body immersed or floating in a fluid is buoyed up by a force equal to the weight of the fluid displaced.
37. Charges on a conductor tend to stay on the surface and to be greatest on the sharp edges and points.
38. The work obtained from a simple machine is always equal to the work put into it less the work expended in overcoming friction.
39. The earth's surface may be elevated or lowered by interior forces.
40. An induced current always has such a direction that its magnetic field tends to oppose the motion by which the current was produced.
41. The electrical current flowing in a conductor is directly proportional to the potential difference and inversely proportional to the resistance.
42. Incandescent solids and liquids emit all wave lengths of light and give a continuous spectrum.
43. All materials offer some resistance to the flow of electric current, and that part of the electrical energy used in overcoming this resistance is transformed into heat energy.
44. All matter is composed of single elements or combinations of several elements and can be analyzed by chemical processes and divided into these constituents.
45. The dimensions of an image produced by a lens or a mirror are to the dimensions of the object as their respective distances from the lens or mirror are to each other.
46. Energy is often transmitted in the form of waves.
47. An electric current may be produced in three ways; by rubbing or friction, chemical action, and the use of magnets.
48. Electrostatic induction is the separation of charges on a conductor through the influence of a neighboring charge.
49. Dark rough or unpolished surfaces absorb or radiate energy more effectively than light, smooth or polished surfaces.
50. When a gas expands, heat energy is converted into mechanical energy.
51. When elevations or depressions are created upon the surface of the earth, the elevations are usually attacked by the agents of erosion, and the materials are carried to the depressions.
52. Bodies in rotation tend to fly out in a straight line which is tangent to the arc of rotation.
53. Heat is conducted by the transfer of kinetic energy from molecule to molecule.
54. Like magnetic poles always repel each other and unlike magnetic poles always attract each other.
55. Gases may be converted into liquids by reducing the speed of their molecules.
56. The mass of any substance set free by electrolysis is proportional to the current flowing and the time of flow; if the quantity of electricity is kept constant, the masses of the various substances set free are proportional to their electro-chemical equivalents.
57. The sum of the reciprocals of the conjugate focal length of a lens or mirror equals the reciprocal of the principal focal length.
58. Each combustible substance has a kindling temperature which varies with its condition but may be greater or less than the kindling temperature of some other substance.
59. The curvature of a wave front will be changed a given amount by a lens; namely, 1/F.
60. Light travels in straight lines in a medium of uniform optical density.
61. The atmosphere of the earth tends to prevent the heat of the earth's surface from escaping, and the earth begins to cool only when the amount of heat lost during the night exceeds that gained during the day.
62. The rate of vaporization decreases with an increase of concentration of the vapor in the gas in contact with the liquid, the temperature remaining constant.
63. When light is reflected, the angle of incidence is equal to the angle of reflection.

64. The colors of objects depend upon what light rays they transmit, absorb or reflect.
65. Condensation will occur when a vapor is at its saturation point if centers of condensation are available and if heat is withdrawn.
66. The volume of an ideal gas varies inversely with the pressure upon it, providing the temperature remains constant.
67. Metals may be arranged in an activity series according to their tendency to pass into ionic form by losing electrons.
68. A gas always tends to expand throughout the whole space available.
69. The amount of heat which a constant mass of a liquid or solid acquires when its temperature rises a given amount is identical with the amount it gives off when its temperature falls by that amount.
70. In the lever the force times its distance from the fulcrum equals the weight times its distance from the fulcrum.
71. Positively charged ions of metals may be deposited on the cathode, as atoms, when a direct current is sent through an electrolyte.
72. The magnitude of an induced e.m.f. is proportional to the rate at which the number of lines of magnetic force change and to the number of turns of wire in the coil.
73. The speed of light in any given substance bears a constant ratio to the speed of light in air.
74. The lower the temperature of a body, the less the amount of energy it radiates; the higher the temperature the greater is the amount of energy radiated.
75. The amount of heat developed in doing work against friction is proportionate to the amount of work thus expended.
76. Suspended particles of colloids have a continuous, erratic movement due to colloidal, molecular, or ion impacts.
77. Every pure liquid has its own specific boiling and freezing point.
78. Electro-magnetic waves may produce electrical oscillation in a condenser circuit which is so adjusted as to oscillate naturally with the same frequency as that of the incoming waves.
79. Electrical power is directly proportional to the product of the potential difference and the current.
80. The risistance of a metallic conductor depends on the kind of material from which the conductor is made, varies directly with the length, inversely with the cross-sectional area, and increases as the temperature increases.
81. Luminous vapors and gases emit only certain kinds of light producing bright-line spectra.
82. Whenever a high frequency oscillating current produces in the field around it oscillating electric and magnetic fields, energy in the form of an electro-magnet wave is transmitted through space.
83. The more nearly vertical the rays of radiant energy the greater the number that will fall upon a given horizontal area, and the greater is the amount of energy that will be received by that area.
84. The solubility of solutes is affected by heat, pressure, and the nature of the solute and solvent.
85. The force of attraction or repulsion between two magnetic poles varies directly as the pole strengthens and inversely as the square of the distance between the poles.
86. A pure chemical substance may be prepared from raw materials through utilization of their physical and chemical properties.
87. The atmospheric pressure decreases as the altitude increases.
88. The speed of chemical reaction is increased by increasing the concentration of any of the reactants; and is decreased by decreasing the concentration of any of the reactants.
89. By means of high frequency generators or vacuum-tube oscillators, sustained or continuous oscillations can be produced in a condenser circuit. Their intensity is made to vary with audio-frequency currents in a transmitter circuit to produce radio waves.
90. In an uncharged body there are as many protons as electrons and the charges neutralize each other while a deficiency of electrons produces a plus charge on a body and an excess of electrons produces a negative charge.
91. The rate of erosion is inversely proportional to the resistance of rocks to decomposition and disintegration.
92. The intensity of illumination decreases as the square of the distance from a point source.
93. No chemical change occurs without an accompanying energy change.
94. When a current-carrying wire is placed in a magnetic field, there is a force acting on the wire tending to push it at right angles to the direction of the lines of force between the magnetic poles, providing the wire is not parallel to the field.
95. Radiant energy travels in waves along straight lines, its intensity at any distance from a point source is inversely proportional to the square of the distance from the source.
96. The energy which a body possesses on account of its motion is called kinetic energy and is proportional to its mass and the square of its velocity.
97. When the resultant of all the forces acting on a body is zero, the body will stay at rest if at rest, or it will keep in uniform motion in a straight line if it is in motion.
98. Elements are made up of small particles of matter called atoms which are alike in the same element (except for occasional differences in atomic weight; *i.e.*, istopes) but different in different elements.

99. The higher the pitch of a note, the more rapid the vibrations of the producing body.
100. Centrifugal force is directly proportional to the square of the velocity, to the mass, and inversely proportional to the radius of rotation.

SUMMARY OF FINDINGS

The data obtained in this study may be summarized as follows:

1. The 264 principles of physical science ranged in final relative values from 20.2 to 89.1 per cent of the maximum possible value of a principle. The median of the values received by all principles was 49.9. Twenty-five per cent, or 66 principles, received values of 63.0 or above; 50 per cent, or 132 principles, received values of 49.9 or above; and 75 per cent, or 188 principles, received values of 38.0 or above.

2. The upper 25 per cent of the principles includes 55 of those classified as belonging in the field of physics, 8 from the field of chemistry, and 3 from the field of geology. The lowest 25 per cent of the principles includes 36 principles of physics, 27 principles of chemistry, and 3 principles of geology.

3. The highest ranking half of the principles includes 108 principles of physics, 28 principles of chemistry, and 6 principles of geology. These figures become somewhat more meaningful when expressed in terms of percentages of the total number of principles from each specialized area. Thus, approximately 60 per cent of the 181 principles of physics, exactly 40 per cent of the 70 principles of chemistry, and approximately 29 per cent of the 21 principles of geology received relative values equal to or greater than the median value for all principles.

4. A principle of physics received the highest relative value of all of the 264 principles (89.1 per cent), while a principle of chemistry stood second in the list with 88.4 per cent. The highest ranking principle which is representative of the area of astronomy received a relative value of 79.0 per cent, and the highest ranking principle of geology a relative value of 71.8 per cent.

CONCLUSIONS

The results of this investigation seem to justify the following conclusions:

1. The fact that principles from each of the specialized areas of physical science received final relative values placing them within the upper twenty-five per cent of all principles, indicates that no one specialized area of physical science is, as a whole, more important than all material drawn from other specialized areas.

2. The conclusion seems justified that, insofar as number of principles may be assumed to be a measure of the relative importance of specialized subject-matter areas, the study of physics has greater value for general education than does the study of chemistry or of geology.

3. There is some indication that a relatively large number of those major concepts which constitute the field of chemistry do not possess high value for general education. This statement would also seem to be equally true of geology.

4. The high relative value (79.0 per cent) received by the principle "movements of all bodies in the solar system are due to gravitational attraction and inertia" may be considered to reflect the importance for general education of including some content drawn from the specialized field of astronomy.

USES OF THE STUDY

It is hoped that this study may be of value to teachers, supervisors, curriculum builders, and textbook authors, on all grade levels from the elementary school through the junior college, in the following ways:

1. As one index of the relative values for general education, or principles of physical science and therefore of the degree of emphasis which should be placed on the development of functional understandings

of these principles in courses organized for the purpose of meeting the needs of general education.

2. As a source of a comprehensive list of carefully worded principles of physical science.

3. As a source of materials usable (1) in building instructional or source units for use in science courses at the different grade levels of elementary and secondary schools, (2) in the construction of evaluative instruments for use in any class in physical science below the level of the junior college.

Abstracts

GENERAL EDUCATION

DAVIS, MARY HOUSTON, AND ROSE, ELIZABETH LAMAR. "Making Theories Work." *The High School Journal* 25: 251–260; October, 1942.

Although this is a general article it might be profitable for those interested in the teaching of science to make their own applications of this article, with examples from their own field. The article opens by arguing that in spite of the ability to mouth the latest terminology and phrases of modern educational theory, many teachers revert to archaic methods in actual practice. The author describes such teachers in the following words: "These teachers are simply textbooks wired for sound. Their classes are teacher-motivated and teacher-controlled. Their children are passive listeners, taking little part in their own education. . . ." Three reasons for this condition are given and discussed. Most significant of the three is that teacher training procedures have separated theory of teaching from subject-matter which illustrates it. This smacks of the outmoded phrase "professionalized subject-matter." The reviewer has felt for some time that this approach in teacher training was abandoned too quickly. The criticism of professionalized subject-matter courses by many educators was no doubt deserved, as many foolish things and much superficial teaching was probably done in its name. It may well be, however, that the criticism should have been directed at improving the way in which the theory underlying this approach was applied rather than to condemn the whole approach and brush it lightly aside by condemning it with such phrases as "superficial" and a way of teaching "methods of teaching nothing in particular." The reviewer would like to raise the question as to whether possibly the rather general rejection of professionalized subject-matter courses by teacher training institutions has been rather a case of "throwing out the baby with the bath." The author of the article illustrates his points by examples from a high school English literature curriculum. The science teacher may easily substitute his own illustrations.

—O. E. Underhill.

MILLIKAN, ROBERT ANDREWS. "The Education of a Scientist." *National Education Association Journal* 31: 107–108; April, 1942.

The reviewer feels that Dr. Millikan has assumed cause and effect relationships in regard to his own education as a scientist with less caution than he uses in his conclusions regarding the nature of the atom. That his experience as a five-year-old jumping out of a boat "introduced me to Newton's third law of motion" in any real sense is questioned. Nor does it seem to be a careful use of language to describe this experience as "my first laboratory experiment on the principle of inertia." Or again his use of the term "extra-curricular" is misleading. After a number of anecdotes concerning his earlier years in the 1880's he says "Can anyone get a better one [education] now? I doubt it." Dr. Millikan may be making the mistake of attributing too much weight to the factor of early out-of-school experience and too little weight to the factors of innate intelligence and technical training in his evaluation of "the education of a scientist." It is the reviewer's opinion that many eminent men have modestly attributed their success and achievements to the effect of earlier experiences they may have enjoyed or suffered, either in or out of school, and given too little weight to their own intellectual ability with which they were born. Such individuals may be prone, too, to choose some particular type of experience and credit it with being the cause of certain of their attitudes and abilities in adult life without making any very careful study to establish objectively whether this or some other factor or combination of factors may not have been responsible. Dr. Millikan does recognize, however, the change in intellectual make-up of the school population now that practically all young people remain in school up to the age of seventeen. He believes this is sound in a democracy. He ends with three conclusions (which seem to have no relationship to the personal history of the preceding pages, however) which, somewhat paraphrased are (1) a large fraction of the population is not qualified to succeed in the pursuits for which colleges train, and should hence be steered away from them; (2) we should provide for that fraction, through apprenticeship training, mastery of manual and commercial skills; (3) the public school system must make at least 51 per cent of the oncoming generation reasonably intelligent voters.

—O. E. Underhill.

BAGLEY, WILLIAM C. "The Persisting Prejudice Against the Professor of Pedagogy." *School and Society* 57: 191–193; February 13, 1943.

The stimulation for this paper was an article in the winter number of *The American Scholar* entitled "Pedagogues and Pedagese." In this article, schools of education and professors of pedagogy are severely criticized and held up to scorn. Dr. Bagley points out that such an attack was made more than thirty years and that this attack is crude, cheap, and uninformed. Not only

have education and professors of education held up under these attacks—they seem even to have thrived upon the criticism. This critical attitude toward education and education professors is probably widely held by other teachers in colleges and universities. Surely many "non-education" professors feel superior to the education professors whom they consider to be in the lowest caste of the teaching profession.

—C.M.P.

HALL-QUEST, ALFRED L. "Three Educational Theories: Traditionalism, Progressivism, Essentialism." *School and Society* 56: 452–459; November 14, 1942.

The author briefly summarizes the values accented by each of the three major schools of thought in American education—Traditionalism, Progressivism, and Essentialism. Traditionalism aims to develop man's mental powers through pure knowledge, intellectual symbols and difficult tasks. Progressive education seeks to foster personality and social intelligence by means of wide experiences with current problems and direct contact with objective reality. Essentialism emphasizes the enduring values of man's long historical experience and those essential skills whereby these values may be acquired, to the end that the individual may attain a self-reliant and socially dependable character.

—C.M.P.

DANGLER, EDWARD. "Francis W. Parker: Father of the Activity Program." *School and Society* 56: 370–374; October 24, 1942.

The year 1875 marks a significant date in the history of American education, because Francis W. Parker at Quincy, Massachusetts, initiated the Activity Movement, emphasizing the child as the center of all learning. The article summarizes the educational philosophy, activities, and influence of Colonel Parker as he put into action his theories, first at the Cook County Normal School and later at the Chicago Institute of Pedagogy (now a part of the School of Education of the University of Chicago).

—C.M.P.

AYDELOTTE, FRANK. "American Traditions and World Problems." *School and Society* 56: 57–60; July 18, 1942.

This is an address given at the 16th Commencement exercises of the City College of New York. The author sets forth the thesis that we lost the peace after World War I because we refused to follow American tradition and rather than seizing an opportunity to build a better world, we sought refuge in isolation and neutrality.

Our failure to join and actively support the League of Nations led to disastrous political and spiritual consequences, and finally to the abyss of the present conflict. America, in taking a negative attitude rather than positive, had turned her back upon her great traditions.

—C.M.P.

BRIGGS, THOMAS H. "Cassandra Speaks." *School and Society* 55: 141–149; February 7, 1942.

According to the author the primary need of teachers is "to clarify the understanding, first by ourselves and then by others, of the adult public as well as our pupils, of the meanings of democracy." In order to reasonably plan for the new educational program, teachers need to recognize some of the more important questions we now face. Among these are: (1) "What sort of a new world do we want?" (2) "How can we contribute to clarifying the meanings of democracy?" (3) "How can we prepare youth to share effectively in solving post-war problems?" (4) "How can we learn and teach how to sacrifice willingly for desired general welfare?" (5) "How can we give youth perspective and also appreciation of permanent values?" (6) "How can we learn and teach how to select trustworthy leaders?" (7) "How can we contribute to keep morale high?" and (8) "How can we preserve education by justifying the schools to the public?"

—C.M.P.

WHEELER, JOSEPH L., AND HAWES, MARION E. "Educational Books of 1941." *School and Society* 55: 340–355; March 28, 1942.

Approximately 750 items including pamphlets and books in education published during 1941, are listed under 31 classifications.

—C.M.P.

BURNHAM, PAUL S. "Stability of Interests." *School and Society* 55: 332–335; March 21, 1942.

Strong's Vocational Interest Blank has been administered to certain Yale undergraduates since 1929. To one group of freshmen this interest blank was administered twice, with a one week's elapsed time interval. To another group it was administered in the freshmen year, and again three years later in the senior year. Conclusions: A college student's interests are more stable than his classroom grades but less stable than his intelligence-test scores. Changes in his interests bear little relationship to his college grades, his intelligence, or the courses he takes.

CROSS, E. A. "Information, Please." *School and Society* 56: 561–565; December 12, 1942.

The author cites many specific illustrations of the great deficiencies in high school reading and literature, deficiencies common to both pupil and teacher. The work of aiding pupils in acquiring skills in the use of language and in reading what has been written and printed must not be adjourned while the war is going on.

—C.M.P.

Book Reviews

BEAUCHAMP, WILBUR L., AND MAYFIELD, JOHN C. *Basic Electricity.* Chicago: Scott, Foresman and Company, 1943. 305 p. $1.60.

This text for high school use is based on the official U. S. pre-induction training course outline # PIT 101. It is designed to be used in one semester of the third or fourth year. The content is arranged to provide comprehensive summary material for the less able pupil together with additional information to give wider understanding to those who can profit by it. Experiments which require minimum equipment are grouped at the ends of the chapters of which there are 62 in all.

—O. E. Underhill.

WATERS, EUGENE A. *A Study of the Application of an Educational Theory to Science Instruction.* New York: Bureau of Publications, Teachers College, Columbia University, 1942. 132 p. $1.60.

Some theories of education are defined in terms of implications inherent in statements made by leading educators. Instructional and learning procedures are formulated which are believed to be a means of implementing the theory as previously defined. Outcomes which may be expected to emerge from these procedures are formulated. A classroom situation was utilized to try out the suggested procedures and as a means of analyzing the extent to which the desired ends were reached. Five clearly stated principles of guidance result from the first step, four of which involve selection of content for study and the fifth a method of problem-solving approach. The second step produced six guiding principles for class procedures. The very clearly formulated descriptions or definitions of guiding theory, and the method of working from theory to practice should offer valuable aid to the science teacher in developing functional methods.

The reviewer is somewhat disappointed, however, to find that after setting out to follow a theory which emphasizes (1) functional usefulness rather than the logic of specialized science, (2) personal worthwhileness to the student of problems chosen for study, (3) pupil experience rather than teacher pattern as guides to selection of content; and after setting up class procedures intended to give as wide a freedom as possible to pupil choice, that one of the outcomes, in the words of the author, is "With few exceptions the problems and topics selected by the pupils for study were among those commonly included in conventional physics, chemistry and biology textbooks." In the reviewer's opinion not only were the topics so included, but the form in which they were expressed and studied by the pupils seems to reveal a great dependence on such sources for the suggestion of ideas. Did the type of reference material and method of setting the stage fail to reveal to the pupils problems of a more functional and worthwhile nature in terms of their own life and experiences?

—O. E. Underhill.

CALDWELL, OTIS, AND CURTIS, FRANCIS D. *Everyday Science.* Boston: Ginn and Company, 1943. 664 p. $1.96.

Everyday Science replaces the authors' earlier and extensively used text *Science for Today.* The distinctive features of the earlier book are retained but many new features have been added. The textual material seems to be unusually well-selected and is based upon extensive research investigations plus the rich experience of the authors in many years of teaching and thinking about the science problems of youth and how they may best be presented.

An emphasis has been placed on developing airmindedness and the contributions of science in the postwar environment. The nonscientific vocabulary is limited to the 8,000 commonest words in Thorndike's Teachers' Wordbook. Scientific terms are defined and pronounced at the bottom of the pages. There is also an extensive glossary of scientific terms. Each unit has self-tests, a list of additional activities, projects, problems, how good a scientist are you, books for reference, and a list of motion-picture films.

After an introduction on the world of science, there are fourteen units: (1) "The Air and Man's Use of It," (2) "Water and How We Use It," (3) "Understanding and Using Heat," (4) "How Weather and Climate Affect Us," (5) "Light and Our Uses of It," (6) "The Sun, the Earth, and Other Heavenly Bodies," (7) "The Changing Earth and Wealth Within It," (8) "How the Work if the World is Done," (9) "The Nature and Uses of Magnetism and Electricity," (10) "The Earth's Population," (11) "The Nature and Needs of the Human Body," (12) "Conservation," (13) "Science and Communication," (14) "Science and Transportation."

Although the authors have written numerous other outstanding books, they have never written one as outstandingly excellent as this one. Such texts as is this one, are a valuable contribution to American science teaching and have placed it on a level in which all leaders in science education can well take pride.

—C.M.P.

AREY, CHARLES K. *Science Experiences for Elementary Schools.* New York: Bureau of Publications, Teachers College, 1942. 99 p. $0.95.

This monograph is based on the author's experiences in the elementary science laboratory for

classroom teachers of science, established at Teachers College. Based on the premise that there is no substitute in education for firsthand experience and that elementary teachers vitally need this experience with science materials which are suitable for children, a number of experiments illustrate fundamental principles of science, yet are within the range of understanding of elementary school children. Most of the experiments suggested in this monograph can be performed with equipment obtained from the home, the schoolroom or the local stores. Elementary teachers of science should welcome this most timely, useful treatise based on successful classroom use. There are 29 suggested experiments with plants; 18 having to do with the atmosphere; 9 deal with materials of the earth; 5 illustrate principles of seasonal change and earth and moon movements; 35 relate to the fields of magnetism, static electricity and current electricity; and 20 present experiences relating to heat, light and sound.

—C.M.P.

TODD, JAMES CAMPBELL, AND SANFORD, ARTHUR HAWLEY. *Clinical Diagnosis by Laboratory Methods.* Philadelphia: W. B. Saunders, 1943. 857 p. $6.00.

This is a thorough treatment of the various techniques in laboratory clinical diagnosis for the medical student, teacher, doctor or laboratory worker. Much new material is included in this revision. It covers examinations of sputum, urine, blood, gastric and duodenal contents, feces, besides sections covering clinical chemistry, animal parasites, seridiagnostic methods, bacteriological methods, vaccines, skin, tests, etc.

—O. E. Underhill.

BABOR, JOSEPH A., AND MACALPINE, J. KENNETH W. *How to Solve Problems in Qualitative Analysis.* New York Thomas Y. Crowell and Company, 1939. 89 p. $0.75.

After an opening section on mathematical operations sections follow on concentration of solutions, weak electrolytes, solubility-product principle, ionization constant and solubility product, the water equilibrium, hydrolysis and complex ions. Each section discusses general principles briefly, solves typical problems and provides further problems (with answers) for practice.

—O. E. Underhill.

POLLOCK, THOMAS CLARK, SPAULDING, JOHN GORDON, AND READ, ALLEN WALKER. *A Theory of Meaning Analyzed.* General Semantics Monograph No. 3. Chicago: Institute of General Semantics, 1942. 46 p. $1.50.

The significance of these papers cannot be made clear in a brief review except as the reader may be familiar with the work of Korzybski and the Institute of General Semantics. The first paper by Pollock, is "Critique of I. A. Richards' Theory of Language and Literature." The second paper by Spaulding, is entitled "Elementalism: The Effect of an Implicit Postulate of Identity on I. A. Richards' Theory of Poetic Value." Both of these papers utilize as the basis of their approach the Non-Aristotelian approach to logic as defined by Korzybski in his "Science and Sanity." The supplementary paper by Read, "The Lexicographer and General Semantics," is an interesting and thought-provoking description of a way of clarifying our thinking through applying Korzybski's principle of extension to lexicography. The procedure is to collect contexts in which certain words are found and then compare them for similarities and differences in order to bring out the opposite senses and the emotional connotations which are carried by these words. A number of examples show clearly how easily we are led astray by confusing the name by which we label a thing with the thing itself, and how by emphasizing the similarities by means of which the class is named and ignoring the differences which really exist between individuals of the named class we achieve confusion rather than clarity through language. The significance of this paper, like that of the other two, however, will be largely lost except to those familiar with the Korzybski terminology.

—O. E. Underhill.

KENNEDY, WILLIAM J. *Pre-Service Course in Shop Practice.* New York: John Wiley and Sons, 1943. 337 p. $1.52.

This text is designed for a course to be offered high school seniors and covers the U. S. Pre-Induction Training Outline PIT #103. The shopwork covered is selected on the basis of military needs. Sections deal with the use of common hand and machine tools, layout work and the carrying on of simple operations of the mechanic and carpenter. It includes soldering, wiring and wire splicing, ropes: splicing knots, blocks and rigging.

—O. E .Underhill.

BEAUCHAMP, WILBUR L., CRAMPTON, GERTRUDE, AND GRAY, WILLIAM S. *Guidebook for Look and Learn.* Chicago: Scott, Foresman and Company, 1943. 109 p. $0.84.

Look and Learn uses only pictures around which to build an entire year's science course. Thus, regardless of the pupil's reading ability, he should be able to use *Look and Learn* effectively. There are 72 pages of four-color pictures for children to work with. The Teachers Guidebook, bound in the front of the book, describes in detail the picture-study method of teaching science. An index of science concepts found at the end of the book indicates the amount and kind of science that first-graders can learn working with pictures. The content has been organized around the following broad centers or areas of interest: animals, machines, weather, and plants.

This new type of teaching science may well revolutionize science teaching in the primary grades.

—C.M.P.

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